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E-cigarette Use Among Women of Reproductive Age: Impulsivity, Cigarette Smoking Status, and Other Risk Factors

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Abstract

Introduction: The study aim was to examine impulsivity and other risk factors for e-cigarette use among women of reproductive age comparing current daily cigarette smokers to never cigarette smokers. Women of reproductive age are of special interest because of the additional risk that tobacco and nicotine use represents should they become pregnant. **Method:** Survey data were collected anonymously online using Amazon Mechanical Turk in 2014. Participants were 800 women ages 24-44 years from the US. Half (n = 400) reported current, daily smoking and half (n = 400) reported smoking less than 100 cigarettes lifetime. Participants completed questionnaires regarding sociodemographics, tobacco/nicotine use, and impulsivity (i.e., delay discounting & Barratt Impulsiveness Scale). Predictors of smoking and e-cigarette use were examined using logistic regression. **Results**: Daily cigarette smoking was associated with greater impulsivity, lower education, past illegal drug use, and White race/ethnicity. E-cigarette use in the overall sample was associated with being a cigarette smoker and greater education. E-cigarette use among current smokers was associated with increased nicotine dependence and quitting smoking; among never smokers it was associated with greater impulsivity and illegal drug use. E-cigarette use was associated with hookah use, and for never smokers only with use of cigars and other nicotine products. **Conclusions**: E-cigarette use among women of reproductive age varies by smoking status, with use among current smokers reflecting attempts to quit smoking whereas among non-smokers use may be a marker of a more impulsive repertoire that includes greater use of alternative tobacco products and illegal drugs.

Keywords: smoking; cigarette smoking; tobacco use; electronic cigarettes; tobacco products; women; reproductive period; delay discounting; impulsive behavior

Smoking prevalence in the U.S. has declined substantially over the past approximately 50 years, but smoking rates among women have shown a slower decline (Chilcoat, 2009; Higgins & Chilcoat, 2009; Higgins et al., 2009; Kandel, Griesler, & Schaffran, 2009). Smoking during pregnancy is the leading preventable cause of poor pregnancy outcomes in the US and other developed countries (Bonnie, Stratton, & Wallace, 2007; Cnattingius, 2004; Pauly & Slotkin, 2008). The adverse consequences of smoking during pregnancy or raising children in a smoking environment have led researchers to target women of reproductive age as an important population to study in understanding risk from use of tobacco and nicotine delivery products (e.g., Ahluwalia, Mack, & Mokdad, 2004; Hand, Heil, Sigmon, & Higgins, 2015; Vurbic et al., 2015).

Use of e-cigarettes is increasing rapidly (e.g., Lee, Hebert, Nonnemaker, & Kim, 2014; Lopez & Eissenberg, 2015). However, knowledge regarding vulnerability to use of these products and their health impacts has not kept pace (Benowitz, 2014; Lopez & Eissenberg, 2015; Pisinger & Døssing, 2014; Prignot, Sasco, Poulet, Gupta, & Aditama, 2008). Evidence is beginning to accumulate that e-cigarettes may be less harmful than tobacco cigarettes and at least among adults may be more readily adopted by people trying to quit cigarette smoking (Britton & Bogdanovica, 2014; Goniewicz et al., 2014; Hajek, Etter, Benowitz, Eissenberg, & McRobbie, 2014). Recent reports suggest that users of e-cigarettes in the U.S. tend to be cigarette smokers, White, of younger age, and more educated (e.g., King, Patel, Nguyen, & Dube, 2015; McMillen, Maduka, & Winickoff, 2012; Richardson, Williams, Rath, Villanti, & Vallone, 2014). We know of no prior studies examining e-cigarette use specifically among women of reproductive age.

The current study assessed use of e-cigarettes in female current daily cigarette smokers and never smokers to begin to gain a better understanding of risk factors for use and how they may differ as a function of a woman's cigarette smoking status. We also assessed use of other tobacco and nicotine delivery products to see how use of those products may distinguish e-cigarette users from non-users. Impulsivity is an important characteristic to examine as a risk factor for e-cigarette use considering the robust associations between cigarette smoking and impulsivity (including delay discounting) observed in previous studies (e.g., Bickel & Marsch, 2001; Bickel, Odum, & Madden, 1999). To our knowledge, neither delay discounting nor any other measure of impulsivity has been examined in relation to use of e-cigarettes. Thus we included delay discounting and the Barratt Impulsiveness Scale-11 (BIS) (Patton, Stanford, &

Barratt, 1995) in the present study. The BIS is a widely used measure of trait-level impulsiveness that also has been reported to be related to smoking status (Mitchell, 1999).

The present study was conducted via Amazon Mechanical Turk (AMT), an online crowdsourcing marketplace that brings together individuals offering small jobs for pay with individuals willing to complete web-based tasks for payment. People (called "requestors") who have work to offer post work opportunities called "Human Intelligence Tasks" (HITs). Users (called "workers") can browse available HITs and decide which, if any, to complete. The requestor has access only to the Worker ID number. AMT is being used with increasing frequency and positive results for psychological research (e.g., Buhrmester, Kwang, & Gosling, 2011; Crump, McDonnell, & Gureckis, 2013; Mason & Suri, 2012; Paolacci & Chandler, 2014; Rand, 2012; Shapiro, Chandler, & Mueller, 2013). Prior studies using AMT have found both comparable disclosure of sensitive information such as drug use and sexual behavior and discounting outcomes for AMT participants compared to previous studies conducted in controlled laboratory settings (e.g., Bickel et al., 2014; Herrmann, Johnson, & Johnson, 2015; Jarmolowicz, Bickel, Carter, Franck, & Mueller, 2012; Johnson, Herrmann, & Johnson, 2015).

Method

Participants

Participants (N = 800) were recruited as part of a larger study of educational attainment, impulsivity, and other decision-making biases among cigarette smokers versus never-smokers. For study eligibility, AMT users had to be connected via a U.S. IP address, have had at least 95% of their previous HITs approved, be female, between 24 and 44 years, and a current (past 30 days) daily cigarette smoker or never smoker (<100 cigarettes lifetime). Although the target population was U.S. women of reproductive age, using educational attainment as a risk factor necessitated increasing the conventional minimum age from 15 to 24 years to maximize the likelihood that women had reached their terminal education level. After screening, eligible participants viewed informed consent information and either continued on to the survey to imply consent or exited. Eligible participants who completed the survey received a $2.00 credit to their AMT account. The study was approved by the University of Vermont Institutional Review Board.

Procedure

Data collection occurred in two waves in August 2014 (n = 250) and in December 2014 (n = 550). Participants completed the survey at their own pace, and reported sociodemographics, tobacco cigarette smoking characteristics, use of other tobacco and nicotine products, drug use histories, and impulsivity (additional measures of decision-making biases were completed that will be reported separately).

Tobacco cigarette smoking characteristics and use of e-cigarettes and other tobacco and nicotine delivery products. Current smokers answered additional questions assessing smoking history and current use of nicotine replacement therapies (NRT), and completed the Fagerström Test for Nicotine Dependence (Heatherton, Kozlowski, Frecker, & Fagerström 1991); from this, time to first cigarette dichotomized as $\leq$ 30 min or > 30 min was used as an indicator of nicotine dependence.

All participants reported on their use (every day, some days, or not at all) over the past 30 days and past 12 months for e-cigarettes, cigars, hookah, bidis/cloves, smokeless tobacco, snus, and other tobacco products (see Lee et al., 2014). Use was operationalized as any reported use in the past year, collapsing across some days and every day use.

Drug use history. Drug use questions were adapted from the Addiction Severity Index (McLellan et al., 1992). Participants were considered ever drug users if they reported any lifetime use of illegal substances or misuse of prescription drugs.

Impulsivity measures. All participants completed a Monetary Choice Questionnaire (MCQ) and the Barratt Impulsiveness Scale-11 (BIS). The MCQ is a 27-item measure that assesses delay discounting (Kirby, Petry, & Bickel, 1999). Each item asks participants to choose between a smaller amount of hypothetical money available now and a larger amount available at some delay (e.g., "Would you prefer $54 today or $55 in 117 days?"). Delays range from 7 to 186 days. Three different magnitudes of delayed rewards are presented: small (ranging from $25-35), medium (ranging from $50-60) and large (ranging from $75-85). Presentation of the items followed a fixed order established by Kirby and colleagues (1999).

The following equation was used to quantify the relationship between temporal delay and subjective reward value: $V = A/(1+kD)$, where V is the present value of the delayed reward, A is the undiscounted value of the delayed reward, and D is the delay to receipt of the delayed reward. The parameter k is a free parameter that represents the discount rate (Mazur, 1987; Rachlin, Raineri, & Cross, 1991). Larger k values indicate greater discounting of future rewards.

An overall *k* for all 27 MCQ items was determined using the estimation procedure described by Kirby et al. (1999).

BIS consists of 30 statements describing common impulsive and non-impulsive characteristics (e.g., "I do things without thinking, "I plan tasks carefully") and has demonstrated reliability and validity (Patton et al., 1995). Participants rated the frequency of each item on a 4-point scale: 1 = *Rarely/Never*, 2 = *Occasionally*, 3 = *Often*, & 4 = *Almost Always/Always*. BIS yields a total score (BIS-Total) and three subscores: BIS-Attentional (intrusive/racing thoughts and ability to focus on tasks), BIS-Motor (acting on the spur of the moment and maintaining a consistent lifestyle), and BIS-Nonplanning (desire to plan/think through things and enjoyment of complex tasks).

Statistical Methods

Frequencies and descriptive statistics of participant sociodemographics, impulsivity, and substance use histories were examined. Log transformed *k* values were used in statistical analyses due to the skewed distribution of *k*. Tests of differences were conducted between current smokers and never smokers, and between e-cigarette users and non-users, using Fisher's Exact Test for categorical variables and Wilcoxon Rank Sum Test for continuous variables. Tests of differences in past-month use of e-cigarettes were also conducted between current and never smokers who used e-cigarettes within the past year, as well as within the group of current smokers who used e-cigarettes over the past year, comparing those who smoked more and less than the median number of cigarettes per day (*Mdn* = 13) and those who smoked their first cigarette more and less than 30 minutes after waking. Fisher's Exact Test was used for testing these differences.

A six-step series of multiple logistic regression analyses were conducted to examine predictors of cigarette smoking and e-cigarette use, using purposeful selection of covariates (Hosmer, Lemeshow, & Sturdivant, 2013). First, univariate analysis of each prospective independent variable was conducted, and any variable that differed between comparison groups at $p < 0.25$ was included in an initial, multivariable model. Second, all independent variables identified at step 1 as related to the outcome variable were used to fit a multivariable model. Any variable that was not associated significantly (at $p < 0.05$) with the primary outcome was removed, and reduced models were tested. Third, each independent variable eliminated at steps 1 and 2 were added back into a multivariable model, one at a time, with the variables deemed

significant contributors at the end of step 2. Fourth, the linearity of any continuous variables contributing significantly to multivariable models was examined using fractional polynomial regression (Royston & Altman, 1994) in Stata 13.1 (StataCorp, College Station, TX). Fifth, all possible two-way interactions between variables remaining in a reduced model were tested, one at a time, with all main effects. Any interaction that was significantly associated with the outcome in the presence of main effects was added to the multivariable model. Then, a model with all main effects and every significant interaction was tested together. Again, any interaction that no longer contributed significantly to the model was deleted, until a reduced model with only significant interactions was determined. Sixth, we examined final models' sensitivity and specificity by calculating areas under the ROC curve and producing classification tables.

In addition to examining risk factors of e-cigarette use across the entire sample of respondents, separate exploratory multiple logistic regression analyses were conducted to (a) examine risk factors of e-cigarette use within the groups of current smokers and never smokers and (b) to examine whether e-cigarette use, smoking status and their interaction related to use of cigars, hookah, and other nicotine products.

All analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC) unless otherwise specified. Across all tests, statistical significance was defined as $p < 0.05$ (2-tailed).

Results

Unadjusted Comparisons of Tobacco Cigarette Smokers vs. Never Smokers and E-cigarette Users vs. Non-users

Participant characteristics. Overall, the majority of participants was $\leq$ 32 years old, White, completed at least some college, had above median income, and unmarried (Table 1, far-left column).

Current tobacco cigarette smokers compared to never smokers were less educated, more likely to be White, unmarried, have more children, to have ever used illegal drugs, have lower income, and were less likely to be lactating (Table 1, middle columns). Smoking characteristics of current smokers were typical of regular, moderately dependent smokers.

E-cigarette users (n = 255, 31.9%) compared to non-users were more likely to have some college or an Associate's degree, be White, unmarried, tobacco cigarette smokers, to have ever used illegal drugs, and have lower income (Table 1, far-right columns).

Among tobacco cigarette smokers, e-cigarette users (n = 233, 58.3%) compared to non-users were more likely to have some college or an Associate's degree and to report plans to quit smoking in the next 30 days, using nicotine replacement therapies (NRT), and smoking the first cigarette of the day within 30 minutes of awaking (Table 2, left columns). Among never smokers, e-cigarette users (n = 22, 5.5%) compared to non-users were more likely to have ever used illegal drugs and have lower income (Table 2, right columns).

Delay discounting, BIS-Total, BIS-Motor and BIS-Nonplanning were significantly elevated in tobacco cigarette smokers compared to never smokers (Table 3, Panel A). Regarding e-cigarette use, all BIS scales were significantly elevated in users compared to non-users, while delay discounting did not differ (Table 3, Panel A). Within tobacco cigarette smokers only, e-cigarette users did not differ from non-users on any measures of impulsivity (Table 3, Panel B). Within never smokers only, BIS-Total, BIS-Attentional and BIS-Motor scales were elevated in e-cigarette users compared to non-users (Table 3, Panel B).

Patterns of e-cigarette use. More cigarette smokers than never smokers reported past-year and past-month e-cigarette use (Table 4, Panel A). Additionally, among those who reported e-cigarette use in the past year, cigarette smokers were approximately two-fold more likely than never smokers to also report past month (i.e., current) use (Table 4, Panel B). Finally, among cigarette smokers who reported e-cigarette use in the past year, those who were heavier smokers (> 13 cigs/day) or nicotine dependent (smoked within 30 min of rising) were not more likely to report current e-cigarette use than lighter or non-dependent cigarette smokers (Table 4, Panel C).

Adjusted Comparisons of Tobacco Cigarette Smokers vs. Never Smokers and E-cigarette Users vs. Non-users in the Overall Sample

Risk factors for tobacco cigarette smoking. Delay discounting, BIS-Motor, education, race, and having ever used illegal drugs were significantly associated with cigarette smoking in the final multiple logistic regression model, with no significant interactions (Table 5, Panel A). Regarding delay discounting, odds of cigarette smoking increased by 24% for every one-unit increase in log k. Similarly, odds of cigarette smoking increased by 29% for every five-unit increase in BIS-Motor.

Regarding education, odds of being a cigarette smoker decreased by 68% for women with a BA or higher compared to women with some college/AA. Odds of being a cigarette smoker decreased by 49% for women who were Black compared to White. Lastly, women with a history

of ever using illegal drugs had 3.6 times greater odds of being a cigarette smoker than non-users of illegal drugs.

The final model predicting cigarette smoking had acceptable discrimination with an area under the ROC curve of 0.77; the model had 68.8% sensitivity and 68.4% specificity.

Risk factors for e-cigarette use. BIS-Motor scores, education, smoking status, and having ever used other drugs were significantly associated with e-cigarette use in the multivariate model, with significant interactions of (a) smoking status and BIS-Motor scores and (b) smoking status and having ever used drugs (Table 5, Panel B). Delay discounting did not predict e-cigarette use.

Regarding the interaction of smoking status with BIS-Motor scores, there was no association of BIS-Motor scores with e-cigarette use among cigarette smokers but among never-smokers the odds of e-cigarette use doubled for every five-unit increase in BIS-Motor scores. Regarding the interaction of smoking status and illegal drug use, there was no association of drug use history with e-cigarette use among cigarette smokers, but among never smokers, women with a history of ever using illegal drugs had nearly four times greater odds of being an e-cigarette user compared to non-users of illegal drugs.

Regarding education, the odds of being an e-cigarette user decreased by 49% for women with high school or less compared to women with some college or AA, and decreased by 38% for women with a BA or higher compared to women with some college/AA.

The final model predicting e-cigarette use had excellent discrimination with an area under the ROC curve of 0.85; the model had 76.0% sensitivity and 75.4% specificity.

Separate Exploratory Adjusted Models Predicting E-cigarette Use within Current Tobacco Cigarette Smokers and Never Smokers and Use of Other Nicotine Products

Predicting e-cigarette use among current tobacco cigarette smokers. E-cigarette use among current tobacco smokers was significantly associated with plans to quit smoking in the next 30 days, using NRT, and smoking the first cigarette of the day within 30 minutes of awaking (Table 6, Panel A). The odds of being an e-cigarette user increased by 73% for women trying to quit smoking cigarettes in the next 30 days compared to women not trying to quit. Women who were using NRT had more than 4 times greater odds of being an e-cigarette user compared to women not using NRT. The odds of e-cigarette use increased by 82% among

women who were nicotine dependent compared to those who were not. None of the impulsivity measures predicted e-cigarette use among current smokers.

The final model predicting e-cigarette use among current smokers had poor discrimination, with an area under the ROC curve of 0.626; the model had 84.8% sensitivity and 28.9% specificity.

Predicting e-cigarette use among never cigarette smokers. BIS-Motor, a history of ever using illegal drugs, and lower income predicted e-cigarette use (Table 6, Panel B). Every five-unit increase in BIS-Motor led to 2.4 times greater odds of being an e-cigarette user, and women with a history of ever using illegal drugs had nearly four times greater odds of e-cigarette use than women who had not used illegal drugs. Additionally, the odds of being an e-cigarette user decreased by 73% for women with above median income compared to below median income.

The final model predicting e-cigarette use among never smokers had excellent discrimination with an area under the ROC curve of 0.814; however, the model had 0% sensitivity and 99.7% specificity.

Predicting use of other tobacco and nicotine products. Within the overall sample, 16.8% (*n* = 134*)*, 9.3% (*n* = 74), and 8.8% (*n* = 70) reported past-year use of cigars, hookah, and other nicotine products, respectively. There were significant interactions of current cigarette smoking and e-cigarette use in predicting use of each of these products (Table 7). Being a current cigarette smoker predicted greater odds of use of all products among women who did not report e-cigarette use but not among those who did. Similarly, being an e-cigarette user predicted greater odds of use of all three products among never smokers, but either did not predict (cigars & other nicotine products) or was a weaker predictor (hookah) among current smokers.

Models predicting cigar, hookah, and other tobacco use had acceptable discrimination, with areas under the ROC curve ranging from 0.73 to 0.75. However, in all three cases, models had 0% sensitivity and 100% specificity.

Discussion

The large proportion of e-cigarette users (32%) in this sample of daily cigarette smokers and never smokers permitted what, to our knowledge, is the first examination of associations between e-cigarette use and impulsivity. Impulsivity did not predict e-cigarette use among

current smokers nor did illicit drug use. Instead, e-cigarette use among current tobacco cigarette smokers was largely related to efforts to quit smoking, which is consistent with previous results (e.g., Etter, 2010; Goniewicz, Lingas, & Hajek, 2013; Kralikova, Novak, West, Kmetova, & Hajek, 2013; Pulvers et al., 2014; Rutten et al., 2015). Also consistent with previous results, tobacco cigarette smokers with higher levels of nicotine dependence were more likely to have used e-cigarettes in the past year although not more likely to be past-month (i.e., current) e-cigarette users (Pearson et al., 2014; Pulvers et al., 2014).

A different pattern of results emerged in never smokers. As expected, never smokers were less likely to use e-cigarettes than current cigarette smokers. Moreover, among those who reported e-cigarette use in the past year, never smokers were less likely than current cigarette smokers to also report past-month e-cigarette use suggesting a lower likelihood of transitioning to regular e-cigarette use. The small group of never smokers who were past-year e-cigarette users exhibited greater impulsivity on the BIS-Motor scale and higher prevalence of past illegal drug use compared to never smokers who did not use e-cigarettes, associations not seen among cigarette smokers. Overall, e-cigarette use among never smokers was characterized by a relatively impulsive repertoire that also included a pattern of substance use extending beyond tobacco and nicotine products.

The models from the primary analyses had acceptable to excellent discriminative utility, while, as might be expected, the exploratory models examining e-cigarette use within smoking categories and use of other nicotine products were poorer related to imbalances in sensitivity and specificity. The only observation regarding risk factors of e-cigarette use revealed in the exploratory but not the primary models were the relations to efforts to quit smoking among current smokers. However, as noted above, that general relationship between e-cigarette use and efforts to quit smoking tobacco cigarettes has been noted in several prior reports. Nevertheless, the reliability and generality of these potentially important but also novel observations warrant further research. The association of e-cigarette use with quit attempts underscores the need for additional controlled clinical trials to assess the efficacy of e-cigarettes in facilitating quitting or reducing tobacco cigarette smoking, for which evidence is currently mixed (Khoudigian et al., 2016; Malas et al., 2016).

It merits underscoring that the present study was not designed to estimate prevalence of e-cigarette use among women of reproductive age. Estimating prevalence is most appropriately

done using nationally representative samples, which the current study did not use. Prevalence of e-cigarette use in a nationally representative sample of US women of reproductive age has not yet been reported. Lifetime prevalence of e-cigarette use in a recent US nationally representative sample of both women and men in the 25-44 year age range was approximately 17% (Delnevo et al., 2016). It is clear from the present study and this prior nationally representative sample that US women of reproductive age are using e-cigarettes, especially, although not exclusively, those who are current tobacco cigarette smokers. As such, health care providers working with women of reproductive age may want to query them on their use of e-cigarettes and other tobacco and nicotine delivery products in addition to tobacco cigarettes in order to capture overall levels of exposure.

The present study has several limitations. First, while reproductive age in women is considered to begin at 15 years of age, only women 24-44 years of age were included in the current study. This may limit the generality of the observations to younger age women and adolescents. Second, generality to women with less than a high school education may be limited as they were underrepresented in this sample compared to nationally representative samples (e.g., Vurbic et al., 2015). Finally, this study used a relatively new online data collection platform and a somewhat more educated sample, which has the potential to introduce reporting or sample biases such as the somewhat higher prevalence rates of e-cigarette use mentioned above (Nayak, Pechacek, Weaver, & Eriksen, 2016). These limitations notwithstanding, the current study shows for the first time that among women 24-44 years of age, e-cigarette use among current cigarette smokers is primarily associated with attempts to quit or cut back on cigarette smoking whereas use among non-smokers may be a marker of a more impulsive, riskier behavioral repertoire.

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Table 1. *Participant Characteristics by Tobacco Cigarette Smoking Status and E-cigarette Use*

		Cigarette smoking status			E-cigarette use status		
	All	Current smokers	Never smokers	*p*	E-cigarette users	Non-users	*p*
	(*N* = 800)	(*n* = 400)	(*n* = 400)		(*n* = 255)	(*n* = 545)	
Sociodemographics							
Age							
24-26	157 (19.6%)	67 (16.8%)	90 (22.5%)	0.296	53 (20.8%)	104 (19.1%)	0.792
27-29	155 (19.4%)	75 (18.8%)	80 (20.0%)		47 (18.4%)	108 (19.8%)	
30-32	156 (19.5%)	88 (22.0%)	68 (17.0%)		54 (21.2%)	102 (18.7%)	
33-35	146 (18.3%)	77 (19.3%)	69 (17.3%)		40 (15.7%)	106 (19.5%)	
36-38	84 (10.5%)	40 (10.0%)	44 (11.0%)		25 (9.8%)	59 (10.8%)	
39-41	47 (5.9%)	26 (6.5%)	21 (5.3%)		17 (6.7%)	30 (5.5%)	
42-44	55 (6.9%)	27 (6.8%)	28 (7.0%)		19 (7.5%)	36 (6.6%)	
Race							
White	614 (76.8%)	329 (82.3%)	285 (71.3%)	**0.001**	210 (82.4%)	404 (74.1%)	**0.006**
Black/African-American	81 (10.1%)	29 (7.3%)	52 (13.0%)		14 (5.5%)	67 (12.3%)	
Other	101 (12.6%)	41 (10.3%)	60 (15.0%)		30 (11.8%)	71 (13.0%)	
Education							
High school or less	89 (11.1%)	61 (15.3%)	28 (7.0%)	**<0.001**	30 (11.8%)	59 (10.8%)	**<0.001**
Some college or AA	357 (44.6%)	219 (54.8%)	138 (34.5%)		151 (59.2%)	206 (37.8%)	
BA or higher	353 (44.1%)	120 (30.0%)	233 (58.3%)		74 (29.0%)	279 (51.2%)	
Income above median	571 (71.4%)	271 (67.8%)	300 (75.0%)	**0.028**	169 (66.3%)	402 (73.8%)	**0.036**
Marital status							
Married or remarried	384 (48.0%)	173 (43.3%)	211 (52.8%)	**0.009**	103 (40.4%)	281 (51.6%)	**0.004**

Never married, separated, divorced, widowed	416 (52.0%)	227 (56.8%)	189 (47.2%)		152 (59.6%)	264 (48.4%)	
No. children (M ± SD) [95% CI]	1.1 ± 1.3 [1.0, 1.1]	1.1 ± 1.3 [1.0, 1.3]	1.0 ± 1.2 [.9, 1.1]	**0.033**	1.1 ± 1.2 [1.0, 1.3]	1.0 ± 1.3 [.9, 1.2]	0.057
Pregnant	13 (1.6%)	5 (1.3%)	8 (2.0%)	0.420	4 (1.6%)	9 (1.7%)	1.000
Lactating	28 (3.5%)	8 (2.0%)	20 (5.0%)	**0.033**	5 (2.0%)	23 (4.2%)	0.147
Ever used illegal drugs	299 (37.4%)	212 (53.0%)	87 (21.8%)	**<0.001**	143 (56.1%)	156 (28.6%)	**<0.001**
Smoking Characteristics							
Current Smokers	400 (50.0%)	400 (100%)	0 (0%)		233 (91.4%)	167 (30.6%)	**<0.001**
No. cigarettes smoked/day (*M* ± *SD*) [95% CI]	—	13.2 ± 7.5 [12.4, 13.9]	—		—	—	
Age (years) at first cigarette (*M* ± *SD*) [95% CI]	—	16.3 ± 3.9 [15.9, 16.7]	—		—	—	
Trying to quit in next 30 days	—	171 (42.8%)	—		—	—	
Using nicotine replacement	—	32 (8.0%)	—		—	—	
Time to 1st cig ≤ 30min	—	240 (60.0%)	—		—	—	

Note. Data collected in the U.S. in 2014.
Continuous variables were tested using the Wilcoxon Rank Sum Test. Proportions were tested using Fisher's Exact Test.
Bold indicates $p < 0.05$.

Table 2. *Participant Characteristics for E-cigarette Users vs. Non-users among Current Smokers and Never Smokers*

	Current smokers			Never smokers		
	E-cigarette users (n = 233)	Non-users (n = 167)	p	E-cigarette users (n = 22)	Non-users (n = 378)	p
Sociodemographics						
Age						
24-26	46 (19.7%)	21 (12.6%)	0.405	7 (31.8%)	83 (22.0%)	0.069
27-29	41 (17.6%)	34 (20.4%)		6 (27.3%)	74 (19.6%)	
30-32	53 (22.8%)	35 (21.0%)		1 (4.6%)	67 (17.7%)	
33-35	39 (16.7%)	38 (22.8%)		1 (4.6%)	68 (18.0%)	
36-38	22 (9.4%)	18 (10.8%)		3 (13.6%)	41 (10.9%)	
39-41	17 (7.3%)	9 (5.4%)		0 (0%)	21 (5.6%)	
42-44	15 (6.4%)	12 (7.2%)		4 (18.2%)	24 (6.4%)	
Race						
White	194 (83.3%)	135 (80.8%)	0.549	16 (72.7%)	269 (71.2%)	0.054
Black/African-American	14 (6.0%)	15 (9.0%)		0 (0%)	52 (13.8%)	
Other	24 (10.3%)	17 (10.2%)		6 (27.3%)	54 (14.3%)	
Education						
High school or less	28 (12.0%)	33 (19.8%)	**0.023**	2 (9.1%)	26 (6.9%)	0.159
Some college or AA	140 (60.1%)	79 (47.3%)		11 (50.0%)	127 (33.6%)	
BA degree or higher	65 (27.9%)	55 (32.9%)		9 (40.9%)	224 (59.3%)	
Income above median	158 (67.8%)	113 (67.7)	1.000	11 (50.0%)	289 (76.5)	**0.010**
Marital status						
Married or remarried	95 (40.8%)	78 (46.7%)	0.261	8 (36.4%)	203 (53.7%)	0.128
Never married, separated, divorced, widowed	138 (59.2%)	89 (53.3%)		14 (63.6%)	175 (46.3%)	

No. children (M ± SD) [95% CI]	1.2 ± 1.2 [1.0, 1.3]	1.1 ± 1.3[.9, 1.3]	0.306	0.8 ± 1.0 [.4, 1.3]	1.0 ± 1.3[.9, 1.1]	0.772
Pregnant	3 (1.3%)	2 (1.2%)	1.000	1 (4.6%)	7 (1.9%)	0.367
Lactating	4 (1.7%)	4 (2.4%)	0.723	1 (4.6%)	19 (5.3%)	1.000
Ever used illegal drugs	131 (56.2%)	81 (48.5%)	0.128	12 (54.6%)	75 (19.8%)	**<0.001**
Smoking Characteristics						
No. cigarettes smoked/day (*M* ± *SD*)	13.6 ± 7.3	12.5 ± 7.7	0.086	—	—	
[95% CI]	[12.7, 14.6]	[11.3, 13.7]				
Age (years) at first cigarette (*M* ± *SD*)	16.1 ± 3.9	16.5 ± 4.1	0.287	—	—	
[95% CI]	[15.6, 16.6]	[15.9, 17.1]				
Trying to quit in next 30 days	115 (49.4%)	56 (33.5%)	**0.002**	—	—	
Using nicotine replacement	28 (12.0%)	4 (2.4%)	**<0.001**	—	—	
Time to 1st cig ≤ 30min	151 (64.8%)	89 (53.3%	**0.023**	—	—	

Note. Data collected in the U.S. in 2014.
Continuous variables were tested using the Wilcoxon Rank Sum Test. Proportions were tested using Fisher's Exact Test.
Bold indicates $p < 0.05$.

Table 3. *Impulsivity Measures by Tobacco Cigarette Smoking Status and E-cigarette Use*

Panel A: For Tobacco Cigarette Smoking Status and E-cigarette Use Status Overall

		Cigarette smoking status			E-cigarette use status		
	All (N = 800)	Current smokers (n = 400)	Never smokers (n = 400)	p	E-cigarette users (n = 255)	Non-users (n = 545)	p
Delay discounting ($M \pm SD$)	-4.4 ± 1.6	-4.2 ± 1.5	-4.7 ± 1.6	**<0.001**	-4.3 ± 1.5	-4.5 ± 1.7	0.068
BIS-Total ($M \pm SD$)	59.4 ± 11.6	61.2 ± 12.4	57.6 ± 10.5	**<0.001**	61.9 ± 12.4	58.2 ± 11.0	**<0.001**
BIS-Attentional ($M \pm SD$)	15.3 ± 4.3	15.6 ± 4.4	15.0 ± 4.1	0.054	16.0 ± 4.4	15.0 ± 4.2	**0.003**
BIS-Motor ($M \pm SD$)	21.2 ± 4.4	22.0 ± 4.5	20.4 ± 4.1	**<0.001**	22.4 ± 4.4	20.7 ± 4.2	**<0.001**
BIS-Nonplanning ($M \pm SD$)	22.9 ± 5.4	23.6 ± 5.7	22.2 ± 4.9	**<0.001**	23.5 ± 5.6	22.6 ± 5.2	**0.027**

Panel B: For E-cigarette Users vs. Non-users by Tobacco Cigarette Smoking Status

	Current smokers			Never smokers		
	E-cigarette users (n = 233)	Non-users (n = 167)	p	E-cigarette users (n = 22)	Non-users (n = 378)	p
Delay Discounting ($M \pm SD$)	-4.2 ± 1.5	-4.1 ± 1.6	0.194	-4.6 ± 1.3	-4.7 ± 1.6	0.788
BIS-Total ($M \pm SD$)	61.6 ± 12.3	60.5 ± 12.4	0.451	64.7 ± 13.2	57.2 ± 10.2	**0.009**
BIS Attentional ($M \pm SD$)	15.9 ± 4.3	15.3 ± 4.6	0.122	17.0 ± 4.9	14.9 ± 4.0	**0.042**
BIS Motor ($M \pm SD$)	22.3 ± 4.4	21.6 ± 4.6	0.062	23.5 ± 4.3	20.3 ± 4.0	**0.001**
BIS Nonplanning ($M \pm SD$)	23.4 ± 5.6	23.7 ± 5.8	0.428	24.3 ± 5.5	22.1 ± 4.9	0.091

Note. Data collected in the U.S. in 2014.
Continuous variables were tested using the Wilcoxon Rank Sum Test.
Bold indicates $p < 0.05$.

Table 4. *E-cigarette Use*

Panel A: Past-year and Past-month Use for Current Smokers vs. Never Smokers

	All (*N* = 800)	Current smokers (*n* = 400)	Never smokers (*n* = 400)	*p*
E-cigarettes over past month				
Every day	17 (2.1%)	16 (4.0%)	1 (0.2%)	**<0.001**
Some days	140 (17.5%)	134 (33.5%)	6 (1.5%)	
Not at all	638 (79.8%)	246 (61.5%)	392 (98.0%)	
E-cigarettes over past year				
Every day	14 (1.8%)	14 (3.5%)	0 (0%)	**<0.001**
Some days	241 (30.1%)	219 (54.7%)	22 (5.5%)	
Not at all	531 (66.4%)	160 (40.0%)	371 (92.7%)	

Panel B: Past-month Use Among Past-year E-cigarette Users for Current Smokers vs. Never Smokers

	All (*n* = 255)	Current smokers (*n* = 233)	Never smokers (*n* = 22)	*p*
E-cigarettes over past month				
Every day	17 (6.7%)	16 (6.9%)	1 (4.6%)	**0.015**
Some days	137 (53.7%)	131 (56.2%)	6 (27.3%)	
Not at all	101 (39.6%)	86 (36.9%)	15 (68.2%)	

Panel C: Past-month Use Among Past-year E-cigarette Users for Current Smokers: Associations with Heavy Smoking and Nicotine Dependence

	Cigarettes per day			Time to 1st cigarette		
	<13 cigs/day (*n* = 114)	≥13 cigs/day (*n* = 117)	*p*	≤30 min (*n* = 151)	>30 min (*n* = 81)	*p*
E-cigarettes over past month						
Every day	8 (7.0%)	8 (6.8%)	0.798	8 (5.3%)	7 (8.6%)	0.570
Some days	66 (57.9%)	63 (53.9%)		85 (56.3%)	46 (56.8%)	
Not at all	40 (35.1%)	46 (39.3%)		58 (38.4%)	28 (34.6%)	

Note. Data collected in the US in 2014.
Proportions were tested using Fisher's Exact Test. For current smokers, median cigarettes per day = 13.

Bold indicates $p < 0.05$.

Table 5. *Final Models, Estimated Odds Ratios, and 95% Confidence Intervals Predicting Tobacco Cigarette Smoking Status and E-cigarette Use*

Panel A: Tobacco Cigarette Smoking Status

	Wald χ^2	*p*	*OR* (95% CI)
Delay discounting	17.28	<0.001	1.24 (1.12,1.38)
BIS-Motor (for every 5-unit increase)	7.07	0.008	1.29 (1.07,1.56)
Education	52.17	<0.001	
High school or less vs. Some college or AA			1.17 (0.69, 2.01)
BA degree or higher vs. Some college or AA			0.32 (0.23, 0.45)
Race	7.87	0.020	
Black vs. White			0.51 (0.30, 0.86)
Other vs. White			0.68 (0.43, 1.09)
Ever drug use (Yes vs. No)	54.84	<0.001	3.55 (2.54, 4.97)

Panel B: E-cigarette Use Status

	Wald χ^2	*p*	*OR* (95% CI)
BIS-Motor (for every 5-unit increase)	9.72	0.002	
Education	8.49	0.014	
High School or less vs. Some college or AA			0.51 (0.30, 0.90)
BA degree or higher vs. Some college or AA			0.62 (0.41, 0.93)
Smoking status (Current smoker vs. Never smoker)	16.69	<0.001	
Ever drug use (Yes vs. No)	10.26	0.001	
Smoking status x BIS-Motor (for every 5-unit increase)	4.12	0.042	
Current Smokers			1.17 (0.93, 1.47)
Never Smokers			2.10 (1.25, 3.51)
Smoking status x Ever drug use	4.82	0.028	
Ever drug use vs. Never drug use for Current smokers			1.29 (0.86, 1.95)
Ever drug use vs. Never drug use for Never smokers			3.93 (1.59, 9.69)

Note: Data collected in the U.S. in 2014. The initial multivariable model predicting cigarette smoking status (Panel A) included education (high school or less, some college or AA, and BA or higher), race (African-American, White, Other), marital status (married/remarried and other), median income (above or below), no. children, lactation status, ever drug use, delay discounting, BIS-Total, BIS-Attentional, BIS-Motor, and BIS-Nonplanning as predictors. The initial multivariable model predicting e-cigarette use (Panel B) included smoking status, education (high school or less, some college or AA, and BA or higher), race (African-American, White, Other), marital status (married/remarried and other), median income (above or below), no. children, lactation status, ever drug use, delay discounting, BIS-Total, BIS-Attentional, BIS-Motor, and BIS-Nonplanning as predictors.
OR = Odds ratio. CI = confidence interval

Table 6. *Final Models, Estimated Odds Ratios, and 95% Confidence Intervals Predicting E-cigarette Use Among Current and Never Smokers*

Panel A: Among Current Smokers

	Wald χ^2	*p*	*OR* (95% CI)
Trying to quit in next 30 days (Yes vs. No)	6.22	0.013	1.73 (1.13, 2.67)
Using nicotine replacement (Yes vs. No)	7.29	0.007	4.55 (1.52, 13.65)
Time to 1st cig ($\leq$30min vs. >30 min)	7.78	0.005	1.82 (1.20, 2.78)

Panel B: Among Never Smokers

	Wald χ^2	*p*	*OR* (95% CI)
BIS-Motor (for every 5-unit increase)	9.53	0.002	2.35 (1.37, 4.03)
Ever drug use (Yes vs. No)	8.40	0.004	3.87 (1.55, 9.68)
Income (Above median vs. Below median)	7.82	0.005	0.27 (0.11, 0.67)

Note: Data collected in the U.S. in 2014. The initial multivariable model predicting e-cigarette use among current smokers (Panel A) included education (high school or less, some college or AA, and BA or higher), ever drug use, quit status, nicotine replacement status, time to first cigarette (≤30 min. and >30 min.), cigarettes per day, delay discounting, BIS-Motor, and BIS-Attentional as predictors. The initial multivariable model predicting e-cigarette use among never smokers (Panel B) included age (24-26, 27-29, 30-32, 33-35, 36-38, 39-41, and 42-44), education (high school or less, some college or AA, and BA or higher), race (African-American, White, Other), marital status (married/remarried and other), median income (above or below), ever drug use, BIS-Total, BIS-Attentional, BIS-Motor, and BIS-Nonplanning as predictors.
OR = Odds ratio. CI = confidence interval.

Table 7. *Final Models, Estimated Odds Ratios, and 95% Confidence Intervals Predicting Past-year Nicotine Product Use from Tobacco Cigarette Smoking Status and E-cigarette Use Status*

Panel A: Cigars

	Wald χ^2	*p*	*OR* (95% CI)
Cigarette smoking Yes vs. No)	15.29	<0.001	
E-cigarette use (Yes vs. No)	25.25	<0.001	
Cigarette smoking x E-cigarette use	15.89	<0.001	
Current smokers vs. Never smokers for E-cigarette users			0.98 (0.38-2.50)
Current smokers vs. Never smokers for E-cigarette non-users			10.25 (5.23-20.08)
E-cigarette use vs. Non-use for Current smokers			1.36 (0.87-2.12)
E-cigarette use vs. Non-use for Never smokers			14.23 (4.90-41.30)

Panel B: Hookah

	Wald χ^2	*p*	*OR* (95% CI)
Cigarette smoking (Yes vs. No)	0.70	0.404	
E-cigarette use (Yes vs. No)	32.04	<0.001	
Cigarette smoking x E-cigarette use	10.06	0.002	
Current smokers vs. Never smokers for E-cigarette users			0.47 (0.18-1.23)
Current smokers vs. Never smokers for E-cigarette non-users			3.63 (1.60-8.26)
E-cigarette use vs. Non-use for Current smokers			2.23 (1.19-4.17)
E-cigarette use vs. Non-use for Never Smokers			17.17 (5.74-51.34)

Panel C: Other Nicotine Products

	Wald χ^2	*p*	*OR* (95% CI)
Cigarette smoking (Yes vs. No)	11.64	<0.001	
E-cigarette use (Yes vs. No)	14.15	<0.001	
Cigarette smoking x E-cigarette use	6.58	0.010	
Current smokers vs. Never smokers for E-cigarette users			1.43 (0.41-5.06)
Current smokers vs. Never smokers for E-cigarette non-users			12.72 (4.28-37.85)
E-cigarette use vs. Non-use for Current smokers			1.66 (0.94-2.95)
E-cigarette use vs. Non-use for Never Smokers			14.76 (3.08-70.70)

Note: Data collected in the U.S. in 2014. Only current cigarette smoking and e-cigarette use status were included in models predicting cigar use (Panel A), hookah use (Panel B), and use of other nicotine products (Panel C).
OR = Odds ratio. CI = confidence interval.